

Top pair production cross-section measurement at the Tevatron Run 2



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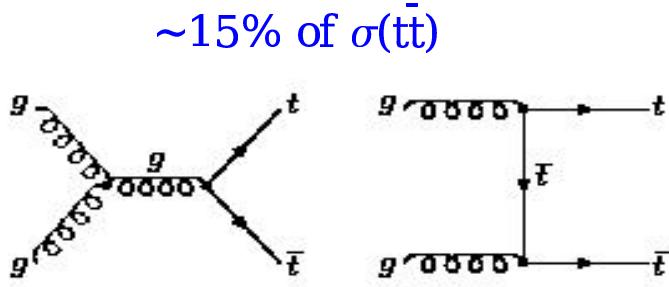
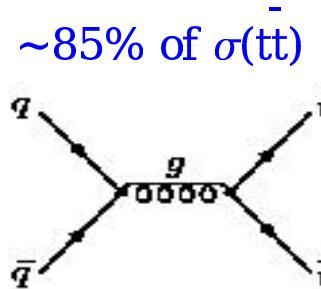


Outline:

- Introduction – top quark production at the Tevatron
- $t\bar{t}$ production cross-section in:
 - dilepton channel
 - lepton+jets channel
 - all jets channel
- Summary

Top quark production at the Tevatron

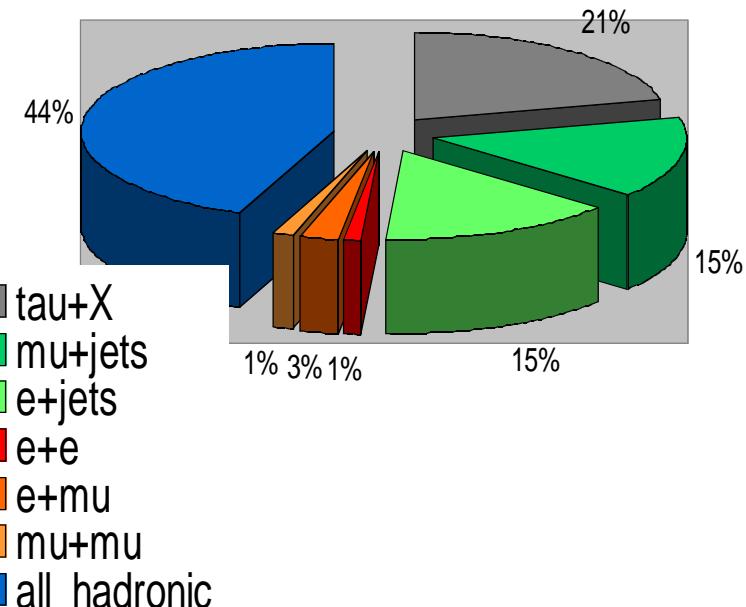
- In proton antiproton collisions at Tevatron energies of 1.96 TeV, top quarks are primarily produced in pairs



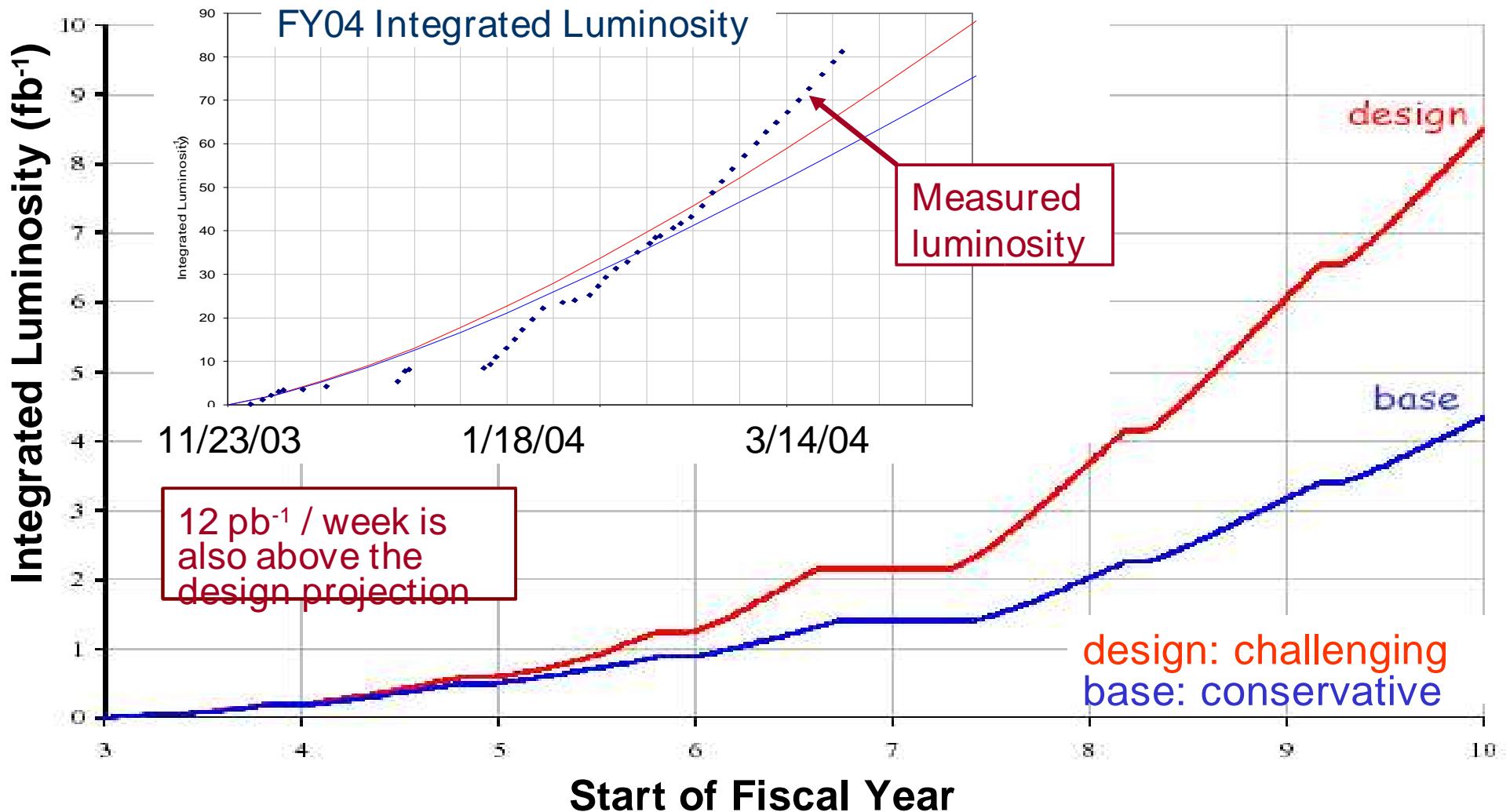
- EW single top production not yet observed

- Top quark decays to Wb in $\sim 100\%$ of cases — final states are determined by the W decay mode

- Three main signatures considered:
 - \Rightarrow Dilepton — 2 high- P_T leptons, 2 b-jets, large E_T^{miss} — $\text{BR}(ee, \mu\mu, e\mu) = 5\%$
 - \Rightarrow Lepton+Jets — 1 high- P_T lepton, 4 jets (2b's), large E_T^{miss} — $\text{BR}(e, \mu + \text{jets}) = 30\%$
 - \Rightarrow All-hadronic — 6 jets (2b's) — $\text{BR}=44\%$

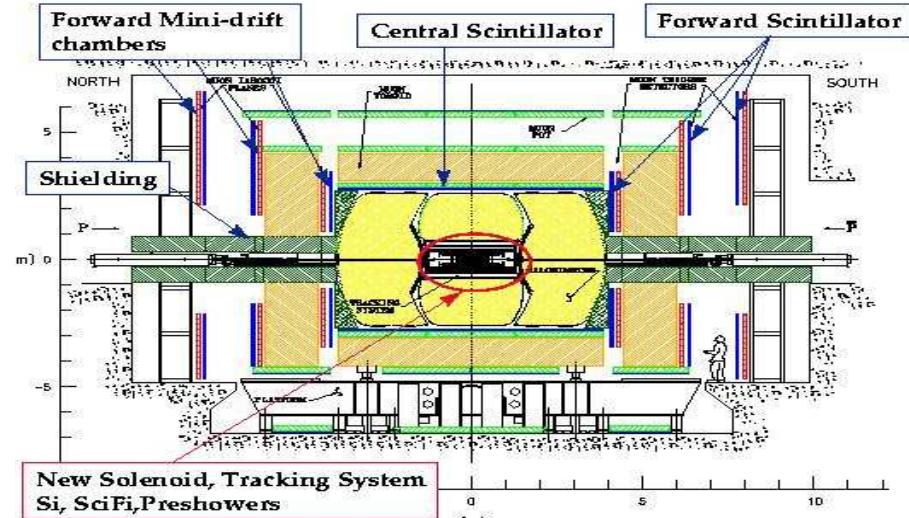
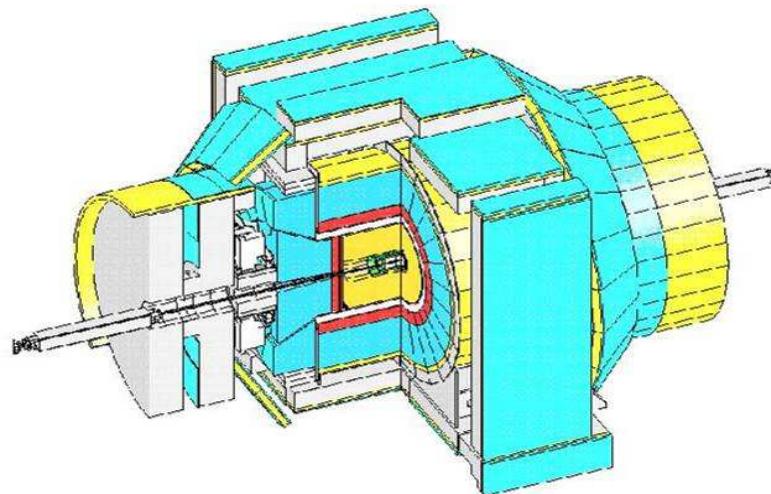


Tevatron performance



New $t\bar{t}$ cross-section results to be shown
obtained with $L_{int} = 126-200 \text{ pb}^{-1}$

Run 2 Detectors



• CDF upgrades

- New Silicon Vertex Detector (SVX) and faster tracking drift chamber (COT)
- New scintillating tile end-plug calorimeters
- Increased $\eta\phi$ coverage for muon detectors
- New scintillator time of flight system

• DØ upgrades

- New Silicon (SMT) and Fiber (CFT) trackers, placed in 2 T magnetic field
- Calorimeter supplemented with the preshower detectors
- Significantly improved muon system

Both detectors:

- b-tagging capability through displaced vertices
- Improved lepton identification systems

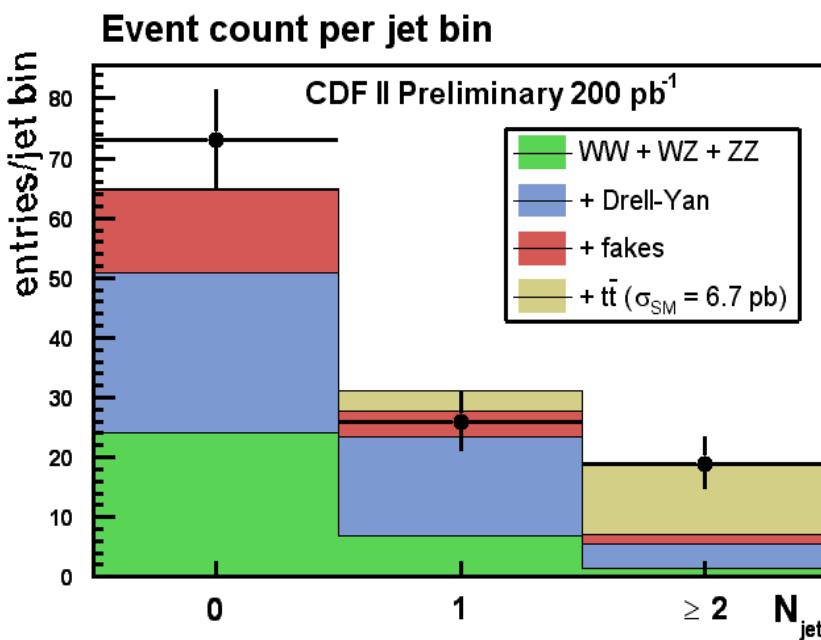


Dilepton cross-section: lepton+track final state

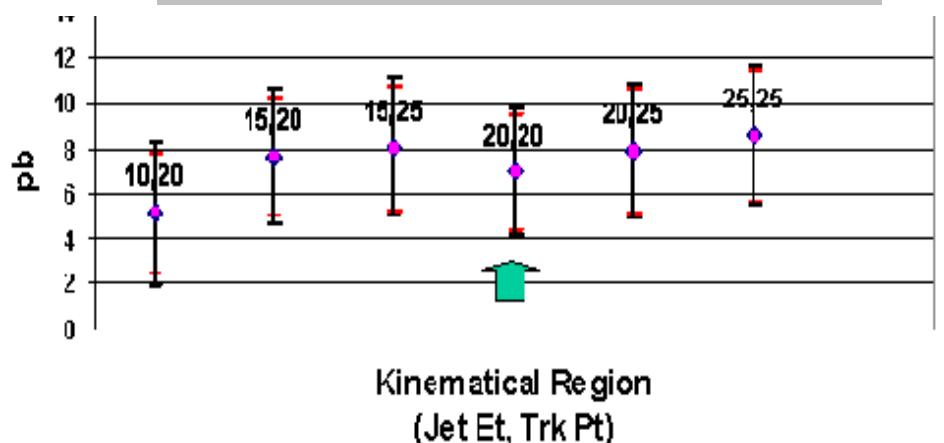
CDF

- Signature: 1 lepton + 1 isolated track, missing ET , 2 central jets
- ~20% higher acceptance than in Run 1
- Backgrounds: $Z/\gamma^* \rightarrow l^+l^-$, WW, WZ, ZZ, W+jets

	njet = 0		njet = 1		njet >= 2	
	#	error	#	error	#	error
top-dilep	0.29	0.04	3.38	0.13	11.53	0.24
Di boson	24.12	0.56	6.89	0.31	1.32	0.14
DY	26.78	5.66	16.59	3.42	4.25	1.00
Total Pbг	50.90	5.69	23.48	3.44	5.57	1.01
Fakes	13.78	1.57	4.16	0.49	1.48	0.19
Total bg	64.68	5.90	27.64	3.47	7.06	1.02
Total pred.	64.97	5.90	31.02	3.47	18.59	1.05
observed	73		26		19	



Measured cross-section for different jet ET and track pT



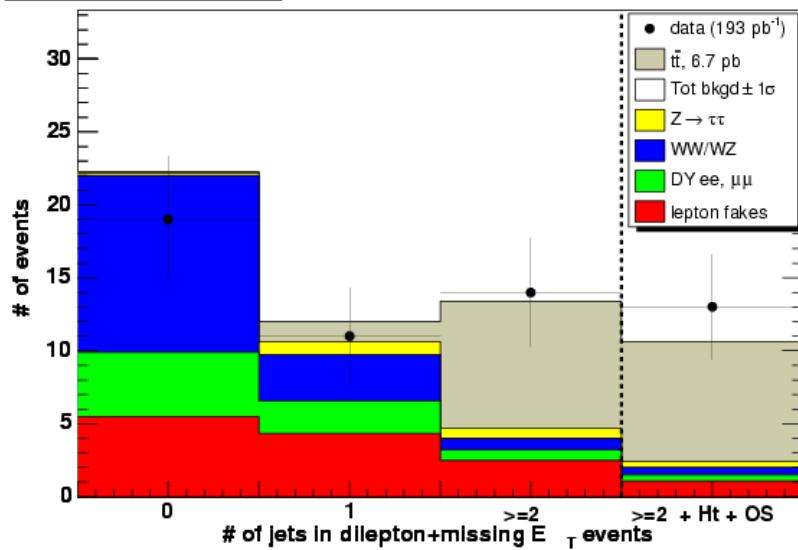
$$\sigma_{tt} = 6.9^{+2.7}_{-2.4}(stat) \pm 1.2(sys) \pm 0.4(lumi) \text{ pb}$$

Dilepton cross-section: ee, $\mu\mu$, e μ final states

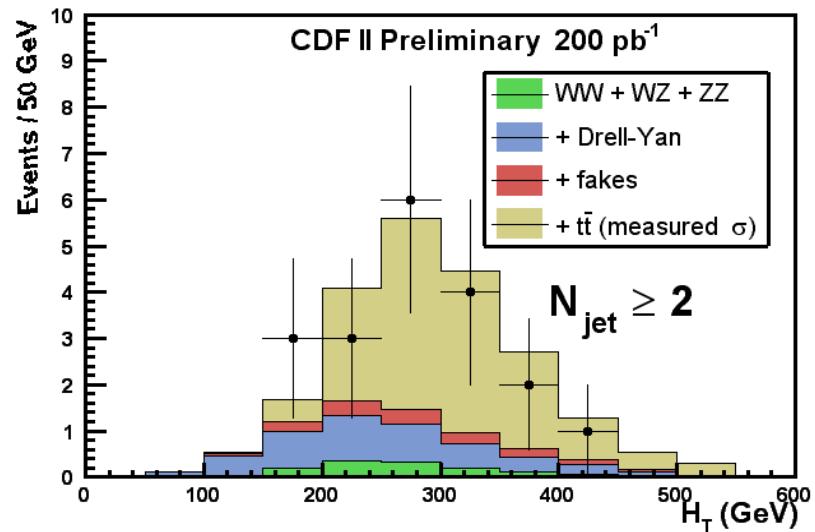
CDF

- Different background composition; Lower acceptance, but higher S/B

CDF II preliminary



Total Transverse Energy (scalar sum)



- Events with 1 “tight” and 1 “loose” e or μ : 1ee, 3 $\mu\mu$, 9e μ

$$\sigma_{tt} = 8.7^{+3.9}_{-2.6}(stat) \pm 1.4(sys) \pm 0.5(lumi) \text{ pb}$$

- Events with 2 “tight” leptons: 1ee, 2 $\mu\mu$, 4e μ

$$\sigma_{tt} = 8.1^{+4.4}_{-3.4}(stat) \pm 1.6(sys) \pm 0.5(lumi) \text{ pb}$$

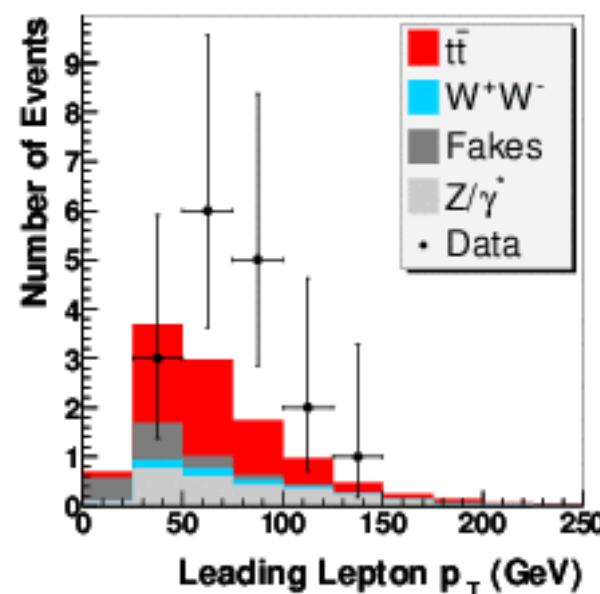
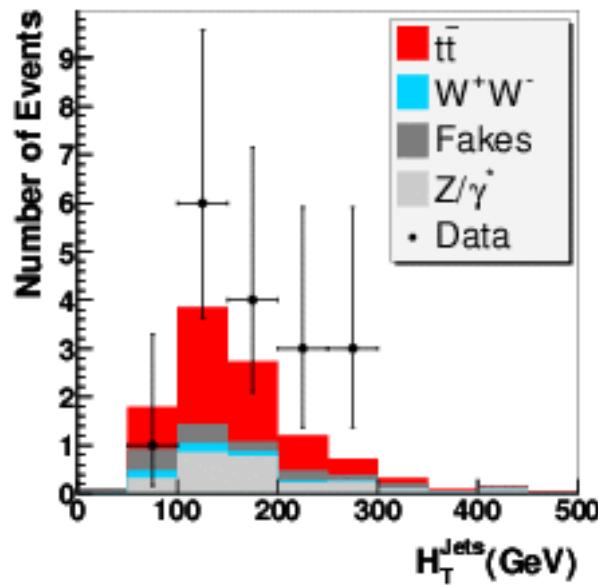
Dilepton cross-section: ee, $\mu\mu$, e μ final states

DØ

- Physics background $Z/\gamma^* \rightarrow l^+l^-$, W^+W^- estimated using MC
- Instrumental background determined from data:
 - Due to missing ET fake in ee channel
 - Due to isolated e/ μ fake in all three channels

ee: 156 pb $^{-1}$
 e μ : 140 pb $^{-1}$
 $\mu\mu$: 143 pb $^{-1}$

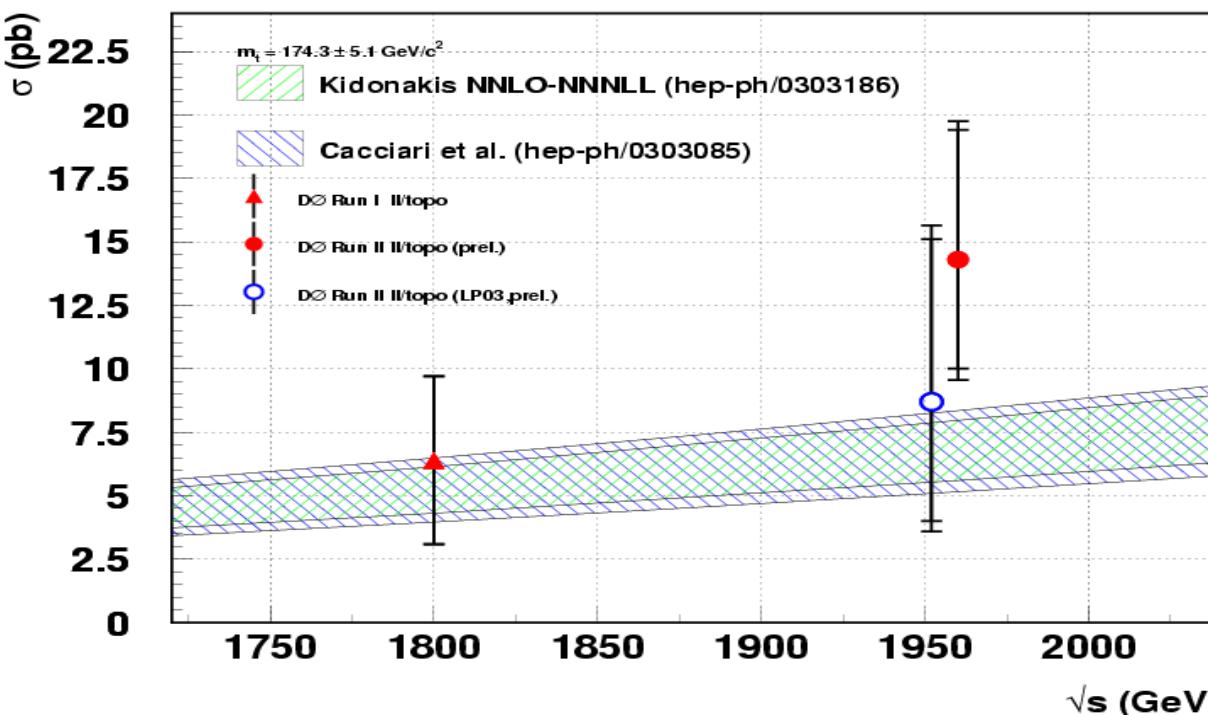
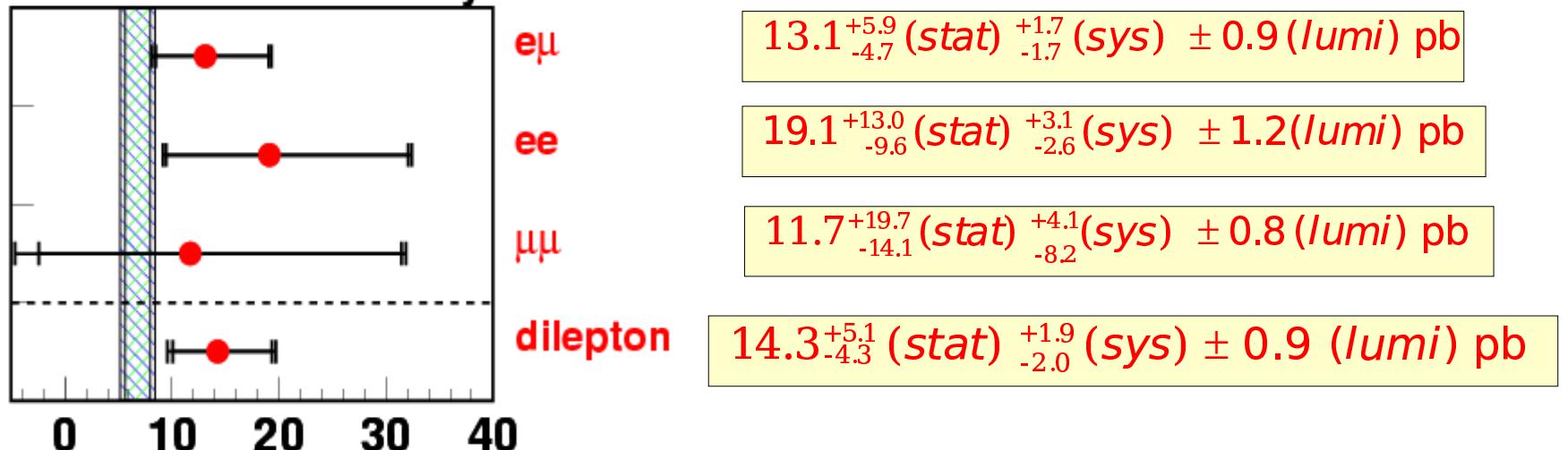
Category	ee	$\mu\mu$	e μ	ll
Z/γ^*	0.15 ± 0.10	2.04 ± 0.49	0.47 ± 0.17	2.66 ± 0.53
WW	0.14 ± 0.08	0.10 ± 0.04	0.29 ± 0.06	0.53 ± 0.11
Fakes	0.91 ± 0.30	0.46 ± 0.20	0.19 ± 0.06	1.56 ± 0.36
Total background	1.20 ± 0.33	2.61 ± 0.53	0.95 ± 0.19	4.76 ± 0.65
Expected signal	1.39 ± 0.19	0.83 ± 0.15	3.77 ± 0.44	5.99 ± 0.50
SM expectation	2.59 ± 0.38	3.44 ± 0.55	4.73 ± 0.49	10.76 ± 0.83
Selected events	5	4	8	17



Dilepton cross-section: ee, $\mu\mu$, e μ final states

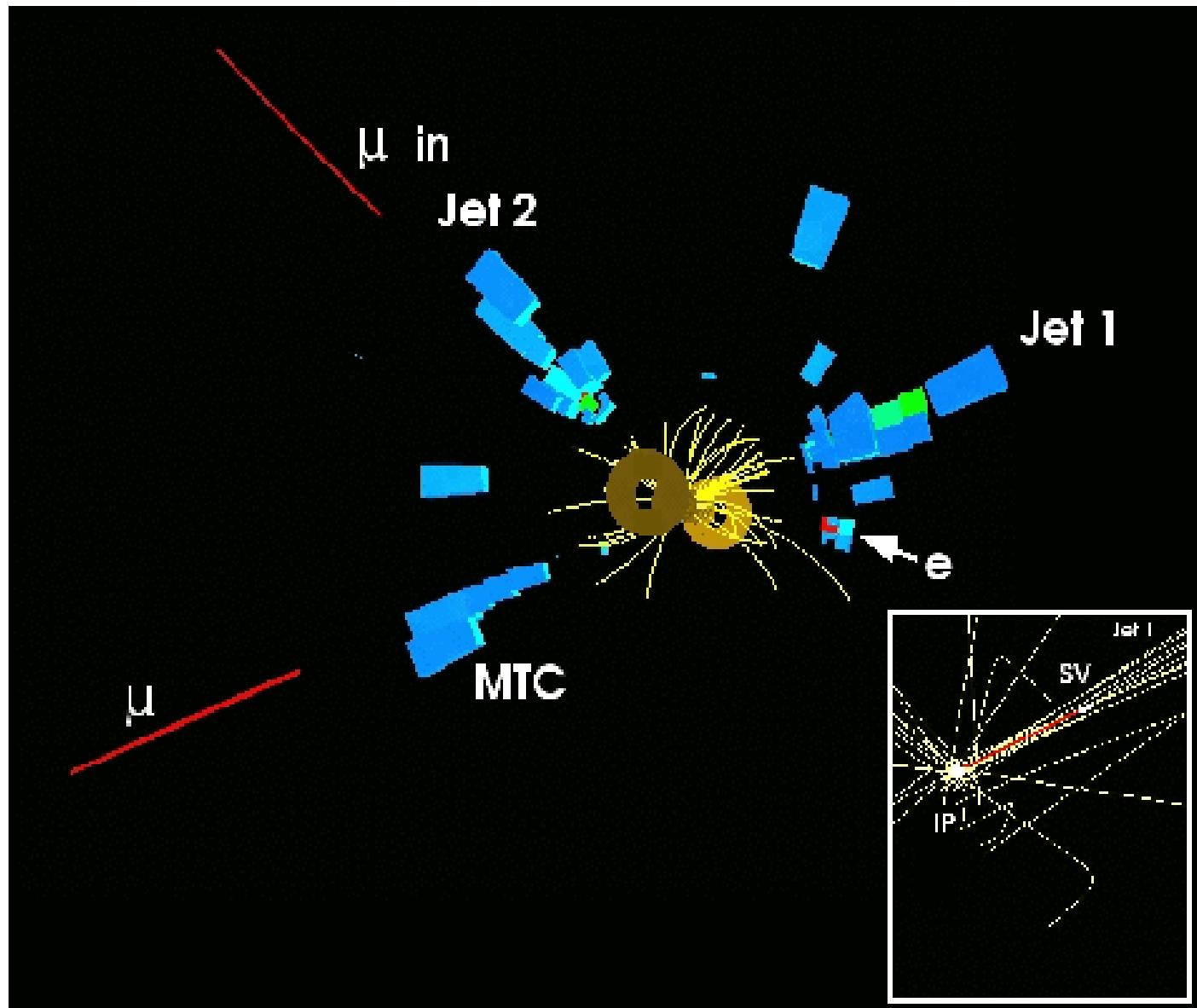
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DØ Run II Preliminary



Dilepton cross-section: $e\mu$ candidate

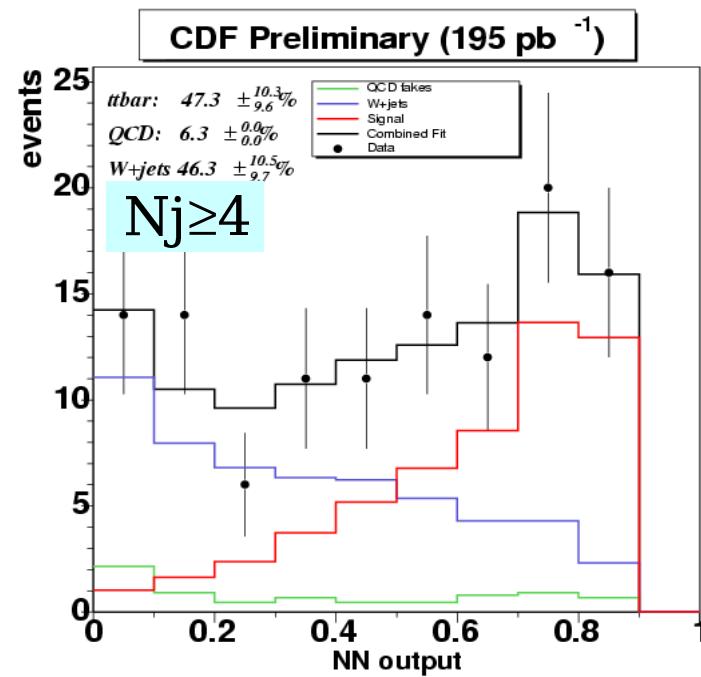
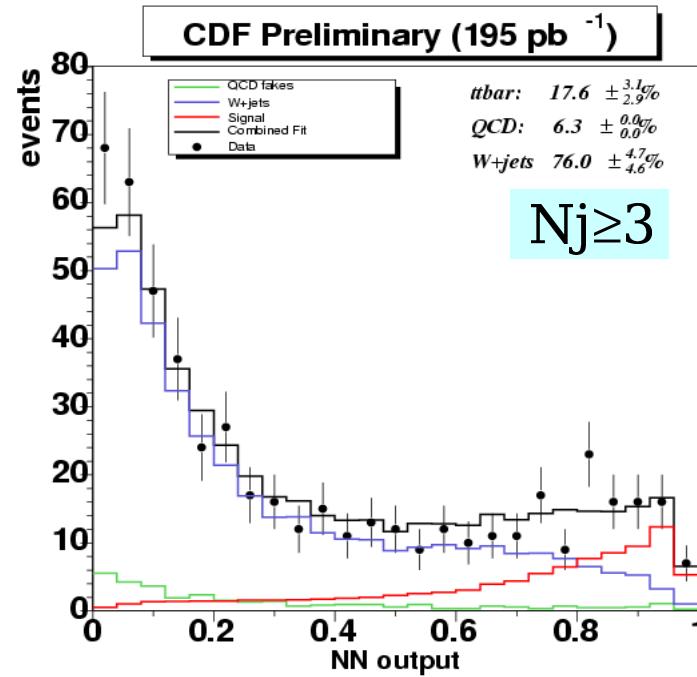
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Lepton+jets cross-section using event topology

CDF

- Signature: high-pT isolated lepton, missing ET and ≥ 3 (≥ 4) central jets
- Dominant background W+jets production
- Other backgrounds: QCD multijet, $Z \rightarrow ll$, WWjet, WZ, single top
- Combine 7 kinematic variables in Neural Network to separate signal from background



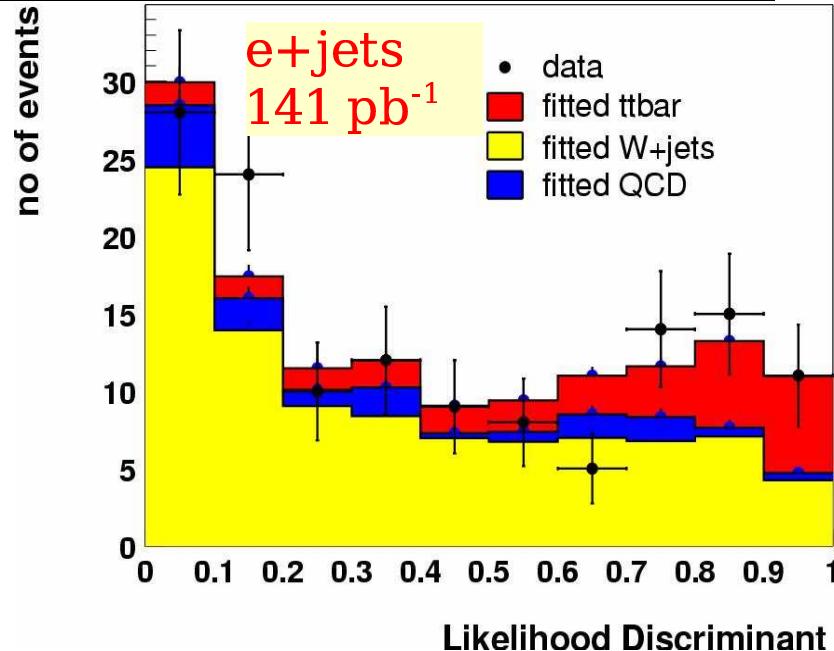
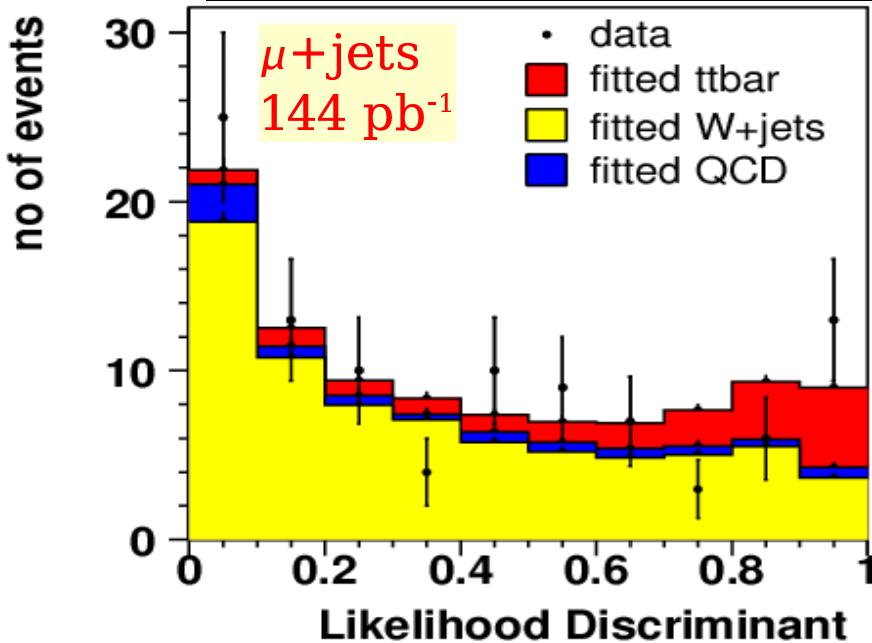
Sample	Events	$t\bar{t}$ fraction	$\sigma(t\bar{t})$
W+ ≥ 3 Jets	519	0.176 ± 0.030	$6.7 \pm 1.3 \pm 1.5$ pb
W+ ≥ 4 Jets	118	0.473 ± 0.100	$7.5 \pm 1.7 \pm 1.6$ pb

Lepton+jets cross-section using event topology

DØ

- Signature: high-pT isolated lepton, missing ET and ≥ 4 jets
- Combine topological variables in event Likelihood. Choose variables with
 - Good signal-to-background discrimination
 - Small correlations
 - Low sensitivity to jet energy scale
- Fit data to signal and background templates \rightarrow extract $t\bar{t}$ fraction

	muons	electrons
$N_{e\nu}$	100	136
fitted N^w	$74.7 + 12.7 - 12.0$	$94.6 + 15.8 - 15.0$
fitted N^{qCD}	$7.1 + 0.9 - 0.9$	$14.1 + 1.2 - 1.2$
fitted $N^{t\bar{t}}$	$17.8 + 9.9 - 8.7$	$27.5 + 12.7 - 11.7$



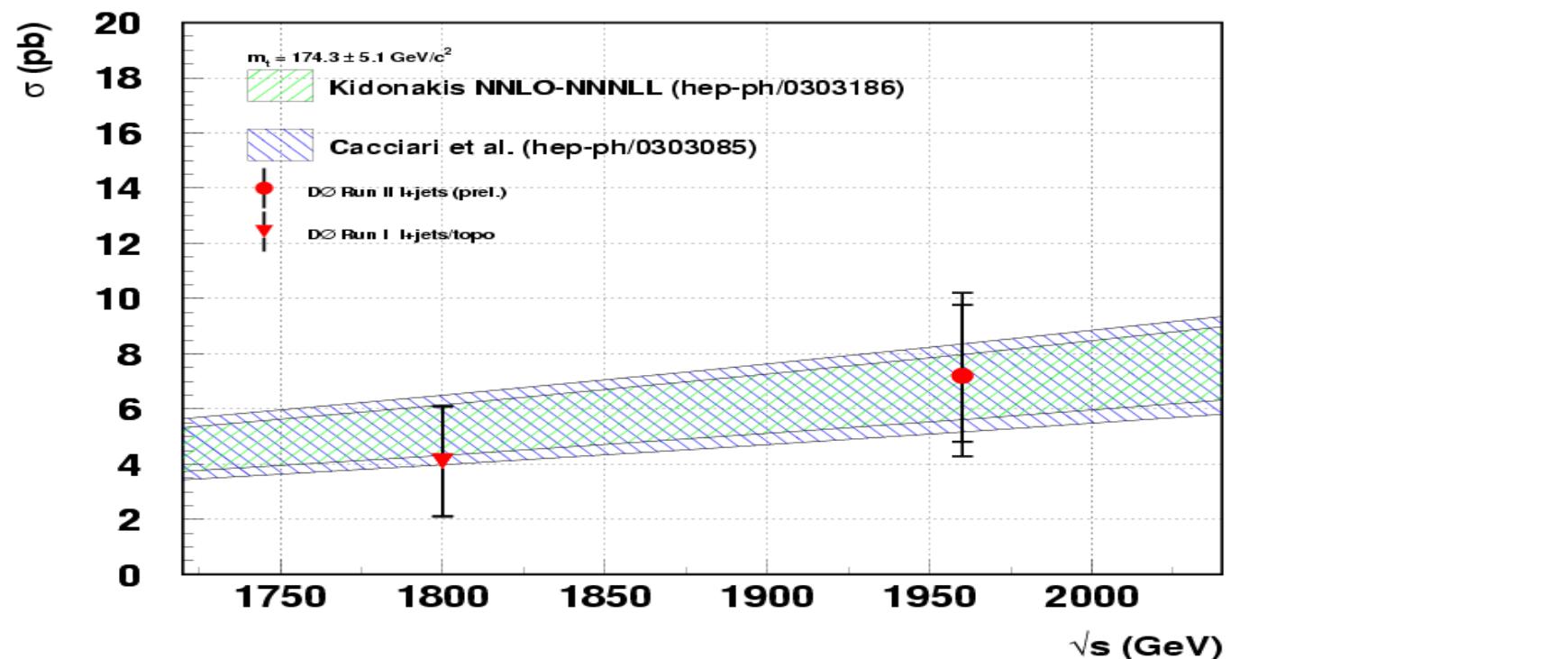
Lepton+jets cross-section using event topology

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DØ Run II Preliminary



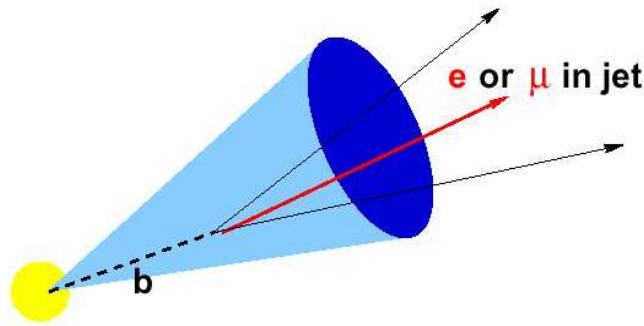
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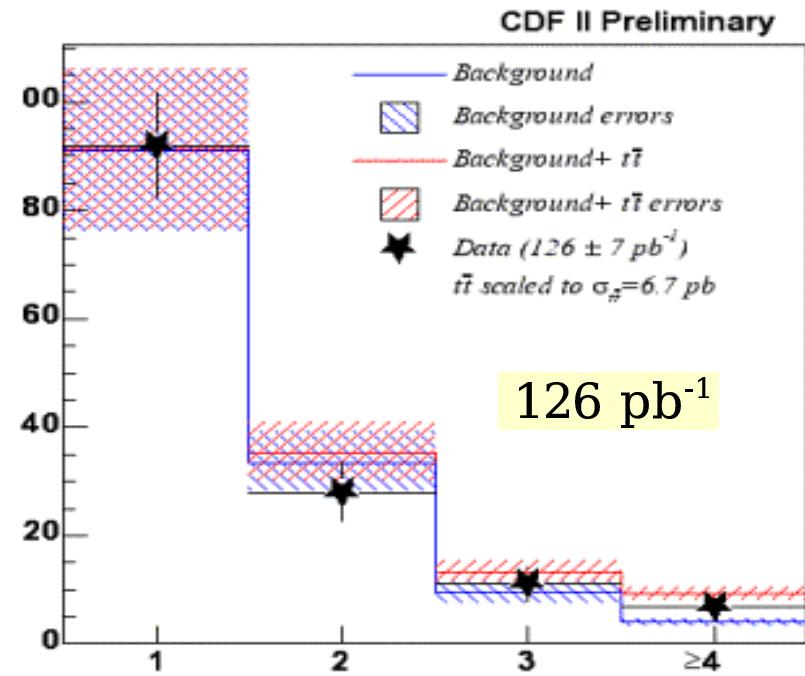
Lepton+jets cross-section using Soft Lepton Tag

CDF

- Two b-quarks produced in every ttbar decays
- $\text{BR}(b \rightarrow l\nu c) \sim 20\%$, $\text{BR}(b \rightarrow c \rightarrow l\nu s) \sim 20\%$
- Leptons from semileptonic b decays are soft and non-isolated
- Use soft muons to tag jets
- Ttbar event tagging efficiency $\sim 15\%$, fake tag rate (QCD jets) $\sim 3.6\%$



- $b \rightarrow \ell\nu c$ (BR $\sim 20\%$)
- $b \rightarrow c \rightarrow \ell\nu s$ (BR $\sim 20\%$)

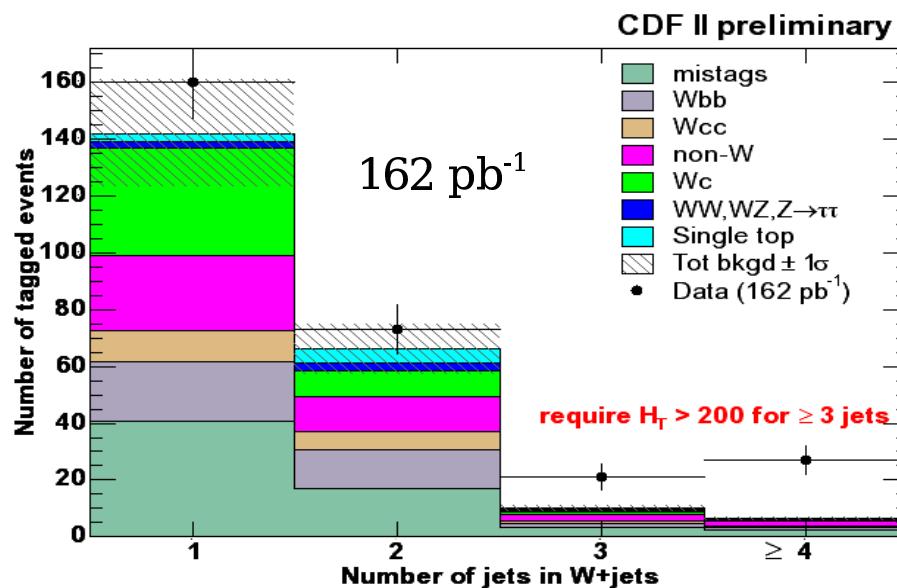
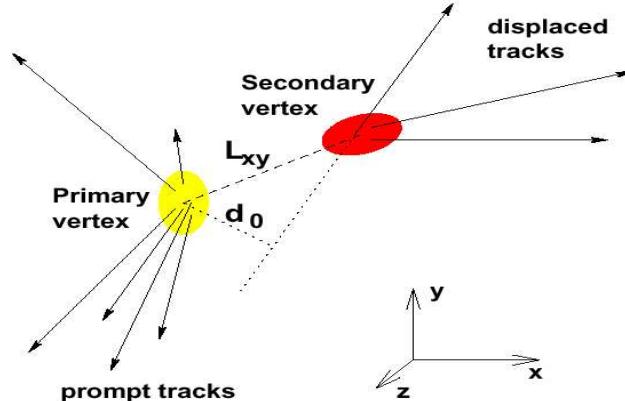


$$\sigma_{\text{tt}} = 4.1^{+4.0}_{-2.8} (\text{stat}) \pm 1.9 (\text{sys}) \text{ pb}$$

Lepton+jets cross-section using SVX tag

CDF

- Two b-quarks produced in every ttbar decays
- B hadrons have long life time: $c\tau \sim 450\mu\text{m}$ + boost \rightarrow travel $\sim 3\text{mm}$ before decay to large track multiplicity
- Ttbar event b-tagging efficiency $\sim 55\%$, fake tag rate (QCD jets) $\sim 0.5\%$

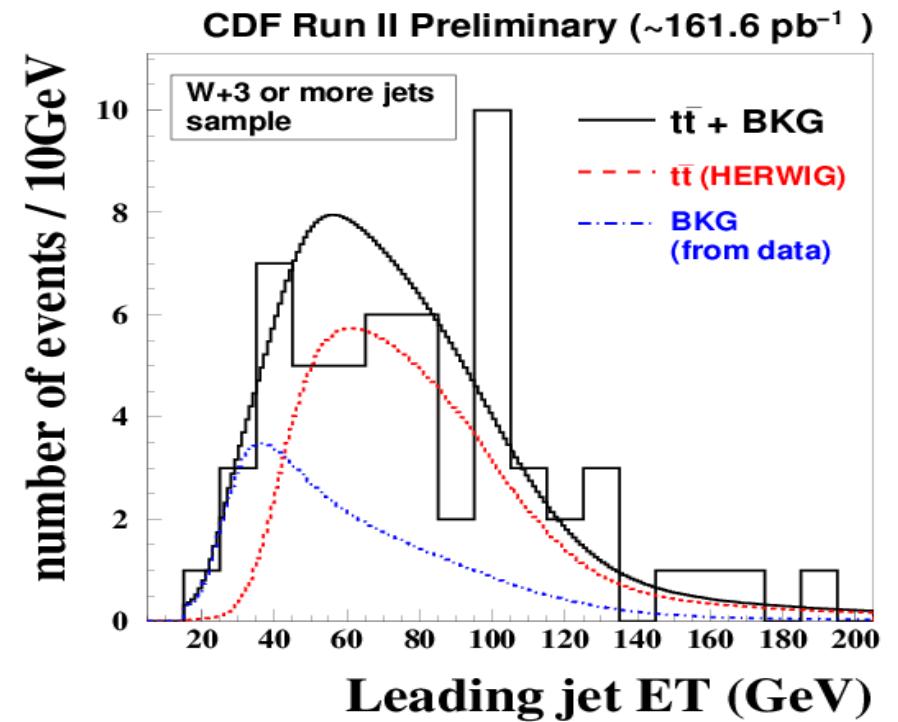
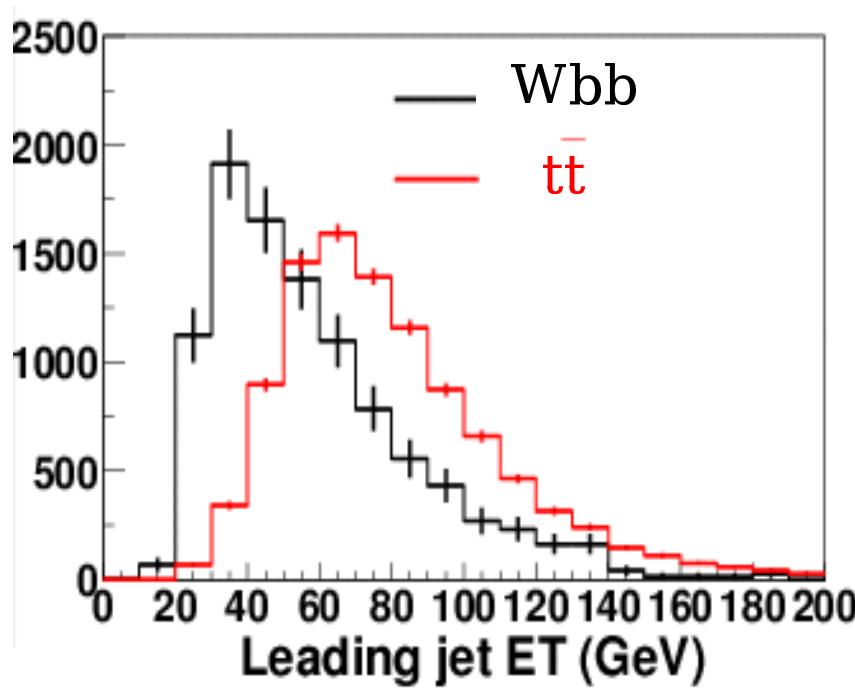


$$\sigma_{\text{tt}} = 5.6^{+1.2}_{-1.0}(\text{stat})^{+1.0}_{-0.7}(\text{sys}) \text{ pb}$$

Lepton+jets cross-section using SVX tag and kinematic fits

CDF

- Use event shape information in tagged events to further separate signal from background
- Examine various kinematic quantities: leading jet ET1, subleading jet ET2, ET1+ET2
- Fit templates to extract signal and background fractions
- Signal templates from ttbar MC, background templates from data: W+3 jets events without b-tag, plus non-W contribution from non-isolated lepton

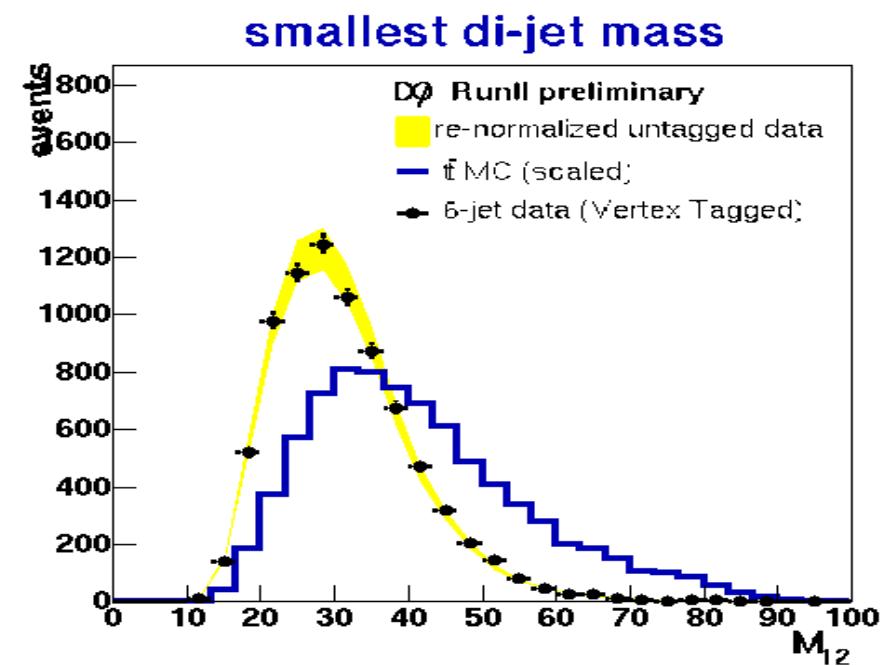
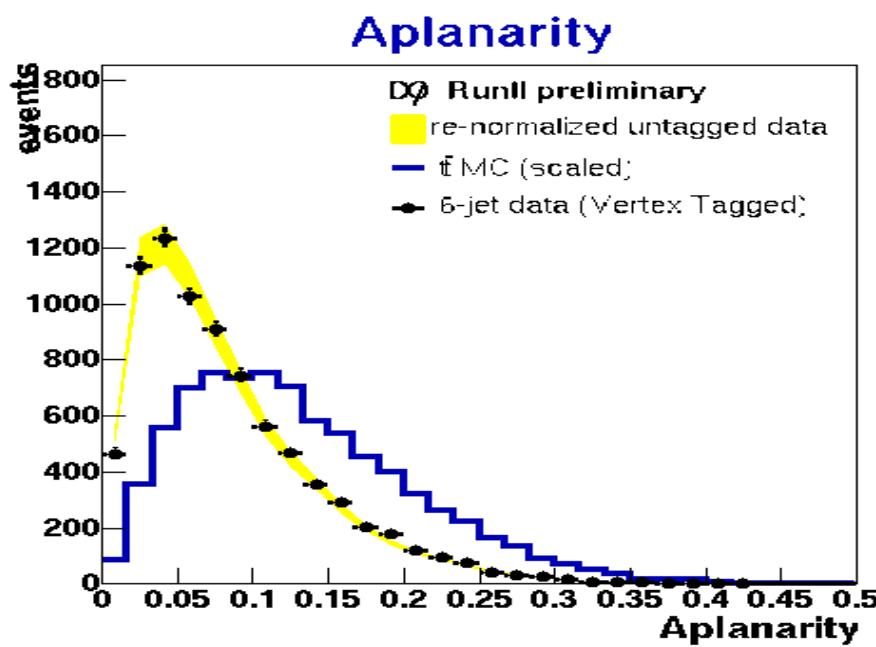
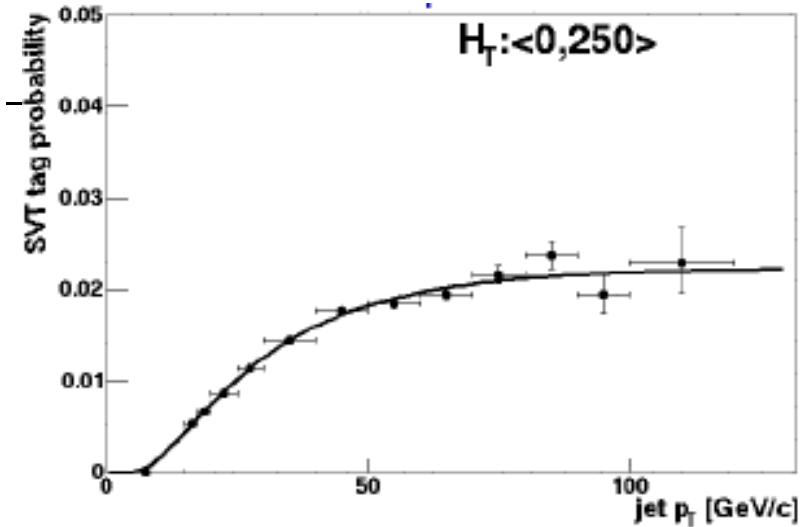


$$\sigma_{\text{tt}} = 6.0^{+1.5}_{-1.8}(\text{stat}) \pm 0.8 (\text{sys}) \text{ pb}$$

All jets cross-section using Secondary Vertex Tag

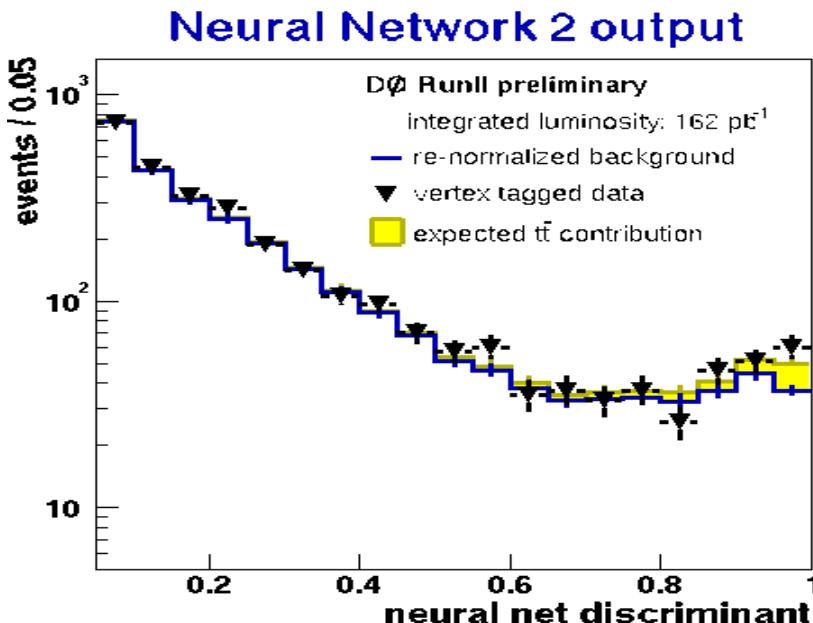
DØ

- Final state: 6 jets, 2 b-quark jets
- Overwhelmed by QCD multijet background
impossible to extract signal without tagging b-jet(s)
- Derive SVT tag rate function in the same multijet events. Apply to untag sample to predict background shape
- Three NNs combine various kinematic variables: apply successive cuts on the outputs

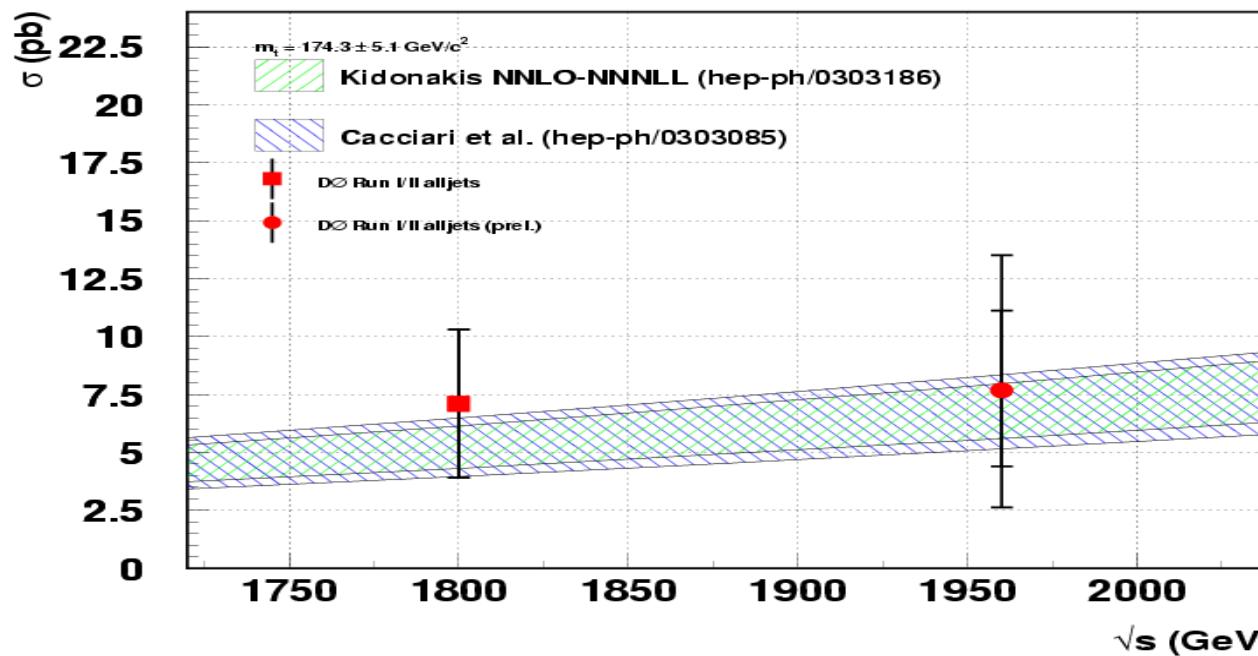


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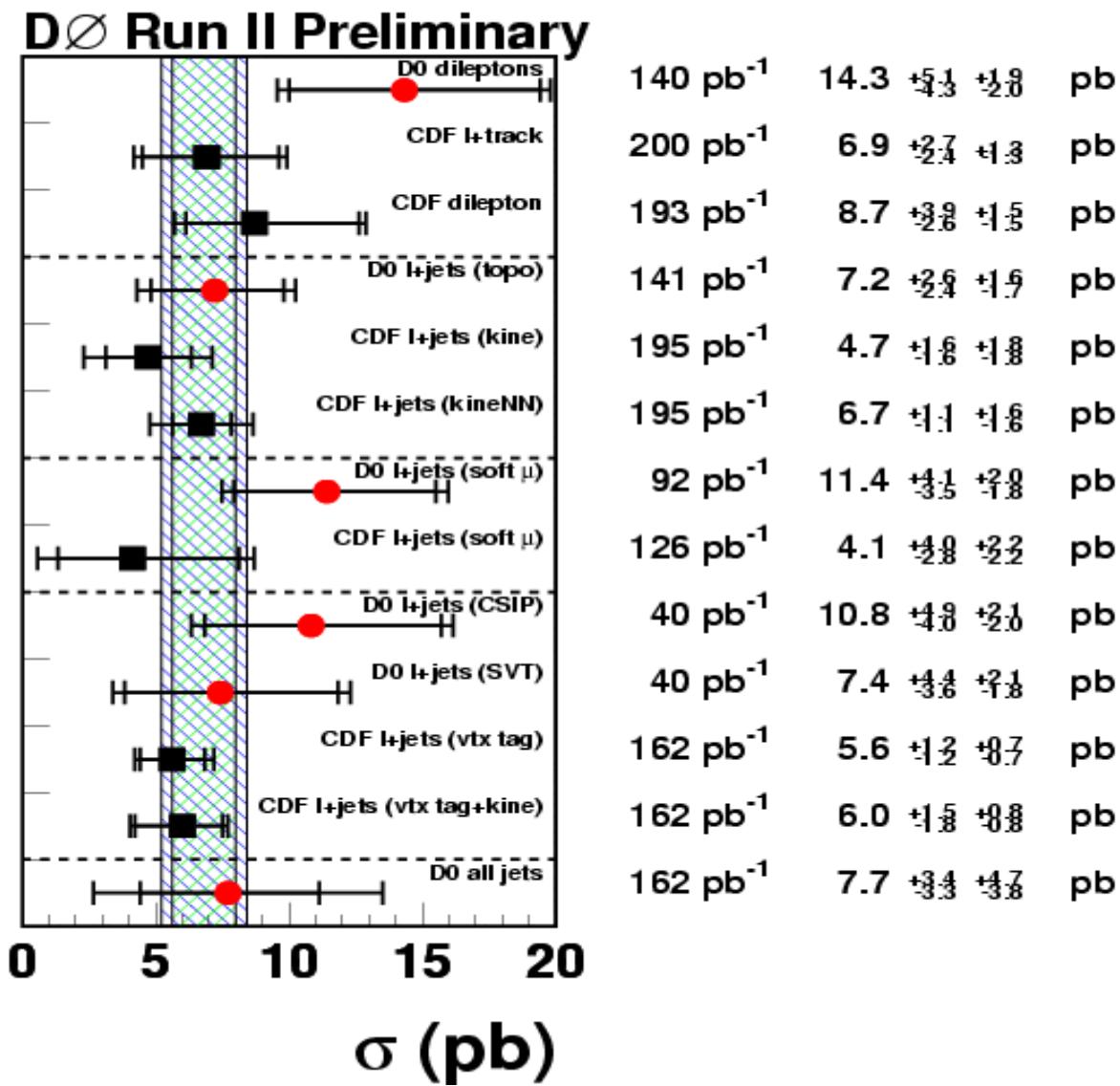
DØ



$$\sigma_{tt} = 8.3 \pm 3.8 \text{ (stat)} {}^{+2.3}_{-2.1} \text{ (sys)} \pm 0.5 \text{ (lumi) pb}$$



Summary



Conclusions

- $t\bar{t}$ signal has been re-established at Tevatron Run 2
- Top pair production cross-section measurements have been delivered for variety of final states. All measurements consistent with the SM expectations – but limited in statistics.
- Expect to reach precisions better than 10% with integrated luminosity of 2fb^{-1} . Any deviation from the SM prediction can signify new physics